2012 Recreational Red Snapper Quota Closure Analysis

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Southeast Regional Office
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Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) requires NOAA Fisheries Service to close recreational red snapper in the Gulf of Mexico when the quota is reached. In April 2011, NOAA Fisheries Service projected the 2011 recreational quota would be met 48 days after the June 1 opening of the fishing season, and established a closure date for the recreational sector of July 19, 2011. Subsequently, the Gulf of Mexico Fishery Management Council requested the red snapper stock assessment be rerun using actual landings for 2009 and 2010. Based on the results of that rerun, the Council's Scientific and Statistical Committee determined that the 2011 red snapper total allowable catch (TAC) could be increased from 7.185 to 7.53 million pounds whole weight (mp ww). In June 2011, the Council requested the entire 345,000 pounds of increased TAC be added to the recreational quota for the 2011 season, resulting in a 3.865 mp ww quota.

In February 2012, the Gulf Council approved a regulatory amendment that proposes to increase the TAC to 8.08 mp ww in 2012. The recreational sector is allocated 49% of the TAC, resulting in 3.959 mp ww quota for 2012. This analysis summarizes landings for the 2011 fishing season and predicts when the 2012 quota will be met, given a season starting on June 1, 2011. Given the short length of the red snapper fishing season and lags in the timeliness of landings data, in-season quota monitoring of red snapper is not possible. Historical red snapper landings adjusted for increases in average weight are used as a proxy for predicting when the 2012 quota will be met. Three different modeling approaches are used to predict the 2012 closure date.

2011 Recreational Red Snapper Landings

Recreational red snapper landings were obtained from three data sources:

1. Marine Recreational Fisheries Statistics Survey (MRFSS), including the For-hire charter survey;
2. Southeast Fisheries Science Center Headboat survey (HBS); and,
3. Texas Parks and Wildlife Department (TPWD) charter and private/rental creel survey.

MRFSS and For-hire red snapper landings are estimated using a combination of dockside intercepts (landings data) and phone surveys (effort data). Landings are estimated in both numbers and whole weight (lbs) by two-month wave (e.g., Wave 1 = Jan/Feb, …, Wave 6 = Nov/Dec), area fished (inland, state, and federal waters), mode of fishing (charter, private/rental, shore), and state (west Florida, Alabama, Mississippi, and Louisiana).

Headboat landings are collected through logbooks completed by headboat operators. Landings (lbs ww) are reported by vessel, day/month, and statistical reporting area (i.e., area 18 = Dry Tortugas off west coast of Florida, …, area 27 = Southeast Texas).

The TPWD creel survey generates estimates of landings in numbers for private/rental boats and charter vessels fishing off Texas. Landings are reported in numbers by high (May 15-November 20) and low-use time periods (November 21-May 14), area fished (state vs. federal waters), and mode of fishing (private vs. charter). To convert TPWD landings in numbers to landings in pounds, red snapper average lengths by mode, wave, and area fished were converted to weights using length-weight conversion formula from SEDAR 7 (2005).

Gulf of Mexico recreational red snapper landings for 2011 totaled 4.59 mp ww, resulting in a 0.73 mp ww recreational quota overage (18.8 percent). MRFSS accounted for 3.77 mp, or 82 percent of the overall landings (Table 1). Headboat landings accounted for 0.63 mp or 13.7 percent of the overall landings (Table 1). Texas Parks and Wildlife landings accounted for 0.20 mp or 4.2 percent of the overall landings (Table 2). For-hire (charter and headboat) landings accounted for 34.4 percent of the total recreational red snapper landings in 2011 and private/rental landings accounted for 65.6 percent of the total recreational landings in 2011.

Table 1. 2011 MRFSS and Headboat red snapper landings (lbs ww) by wave and mode.

	Landings (lbs ww) by Mode			
Wave	**Charter**	**Private**	**Headboat**	**Grand Total**
Jan-Feb	0	0	29,531	29,531
Mar-Apr	0	3070	22,951	26,021
May-Jun	598567	1866414	334,326	2,799,307
Jul-Aug	309933	968788	236,469	1,515,190
Sep-Oct	306	0	0	306
Nov-Dec	0	20988	7,291	28,279
Grand Total	908,806	2,859,261	630,568	4,398,635

Table 2. 2011 TPWD red snapper landings (lbs ww) by season and mode.

	Landings (lbs ww) by Mode		
Season	**Charter**	**Private**	**Grand Total**
Nov 21-May 14	16,659	39,113	55,772
May 15-Nov 20	22,129	117,984	140,113
Grand Total	38,788	157,097	195,885

Red Snapper Average Weights

Season length projections are partially dependent upon estimates of average weight. Between 2007 and 2011, the average weight of a red snapper landed in the Gulf of Mexico increased from 3.32 to 6.39 lbs ww per fish. Between 2010 and 2011, the average weight of red snapper jumped from 5.31 to 6.39 lbs ww. Predicted average weights were obtained from the 2009 stock assessment. The assessment projections were 4-5% higher than reported average weights in 2009 and 2010, but were 4% lower than reported average weights in 2011. Reported average weights were derived from the SEFSC ACL database (2012). The assessment projects the average weight of red snapper to be 6.34 lbs ww in 2012. Methods 1 and 2 evaluated the season length with average weight at projected, at projected plus 5%, and at projected plus 10% (Figure 1).

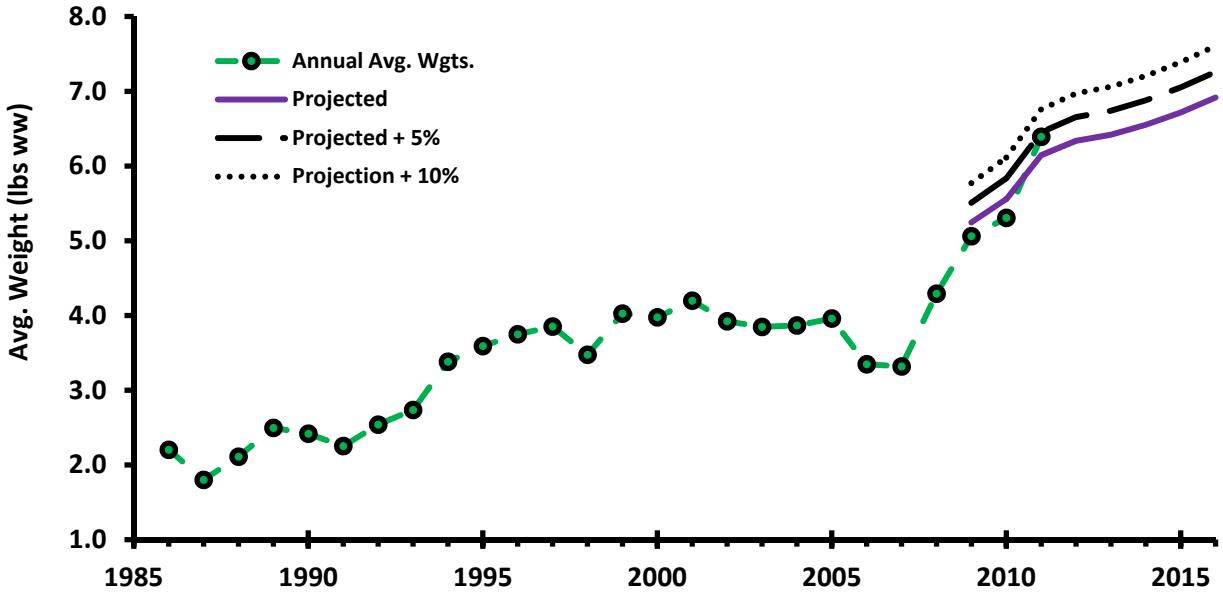

Figure 1. Reported and predicted average weights of red snapper, 2000-2016.

Quota Closure Methods

The start date for the federal recreational red snapper fishing season begins June 1, 2012. The federal season was estimated to be closed when projected landings reached the 3.959 mp quota. Analyses described herein assume all Gulf states, except Texas, will adopt compatible fishing seasons for recreational red snapper in 2012. All Gulf states, except Texas, implemented federally consistent fishing seasons for red snapper in 2011.

This report includes three methodologies for projecting when the recreational quota will be reached in 2012. Method 1 uses a seasonal autoregressive moving average (SARIMA) model to forecast the season length. Method 2 uses historical trends in red snapper fishing effort and catch rates to project when landings will reach the quota. Method 3 uses a linear regression of catch rate during the federal season to predict 2012 landings.

Method 1: Seasonal Auto-Regressive Integrated Moving-Average (SARIMA)

Because red snapper landings have a long-term time-series trend and a seasonal trend, forecasting future catches is particularly well-suited to a SARIMA model (Box and Jenkins 1976). A SARIMA model analyzes and forecasts equally-spaced univariate time series data, predicting a value in a response time series as a linear combination of its own past values, past errors, and past, current, and projected future values of other time series. Because the time series of red snapper recreational catch per day shows strong seasonality, a SARIMA (p,d,q)*(P,D,Q) model was used. The auto-regressive component, designated as p, represents the lingering effects of previous observations. The integrated component, designated as d, represents trends, including seasonality. The moving average component, designated as q, represents lingering effects of previous random shocks (or error). In the SARIMA model, monthly catch per day, in numbers of recreational red snapper was projected as a linear combination of its own past values. Monthly catch-per-day was computed using the SEFSC ACL Recreational Dataset (Apr 2012), which includes headboat, MRFSS, and TPWD landings. MRFSS and TPWD landings are estimated on a bimonthly wave basis, while headboat landings are estimated monthly. Wave landings were subsequently distributed to months as follows:

1. If the federal fishing season was only open for one month within a wave, all landings from the wave were assigned to the federal season.
2. If the federal season was partially open within the two months of the wave, landings were distributed proportional to the number of federal days open within the two months.
3. If the federal season was not open at all during the wave, landings were distributed to months proportional to the number of days in each month.

The Deepwater Horizon/BP oil spill resulted in large fishery closures in the Gulf of Mexico from April-December 2010. To avoid distortion of model predictions due to the unique fishery dynamics caused by spill-related fishery closures, headboat data for April-December 2010 and MRFSS and TPWD data for Waves 2-6 of 2010 were replaced with the average of 2009 and 2011 for the same months. Landings during Jan-Feb 2010 (e.g., Wave 1) were unusually low due to cold and windy weather conditions. To avoid distortions caused by this unusually cold winter when projecting landings for the mild winter of 2012, catch-per-day data for Jan-Feb 2010 were also replaced with the average of 2009 and 2011 for the same months.

Because the SARIMA model also allows for a predictive covariate, abundance at age was obtained from the most recent red snapper stock assessment (B. Linton, SEFSC, pers. comm.) and converted to exploitable abundance using the selectivity at age for the recreational sector (Figure 2; Red Snapper SEDAR Update 2011). Input data are summarized in Appendix 1.

The SARIMA model was implemented using Proc ARIMA in SAS v9.2 for Windows (SAS Institute, Inc., Cary, NC). SARIMA model selection was guided by examination of autocorrelations, inverse autocorrelations, partial autocorrelations, and cross-correlations. Stationarity tests were used to guide differencing selection. Residual diagnostics and Akaike Information Criterion (AIC) values were used to select the final model (see Appendix), which was specified

as a SARIMA(0,0,1)*(1,1,0)*s* model where *s*=12 months, with model fit using conditional least squares. The final model incorporated exploitable abundance as a predictor and captured non-seasonal and seasonal trends in monthly catch per day using an MA(0) model (Moving Average Operator: 1 + 0.08998 B**(1)) combined with an SAR(1) model at a 12 month lag (Auto-Regressive Operator: 1 - 0.19439 B**(12)). A perturbation variable was set to '1' for April and May 2008 to reflect the transition of the opening of the federal season from April 21 to June 1. Red Snapper SEDAR Update (2011) projected values of exploitable abundance were used to seed the forecast of the final model. To validate the predictive utility of the model, the 2011 data were dropped and the model was refit [MA(1): 1 + 0.17361 B**(1), AR(1): 1 + 0.02786 B**(12)] following approaches outlined in Hanson et al. (2006). The actual 2011 values were compared to the retrospective model predictions and a percent prediction error was determined. Model projections in catch-per-day in numbers were converted to pounds using the average weights projected from the Red Snapper SEDAR Update (B. Linton, SEFSC, pers. comm.).

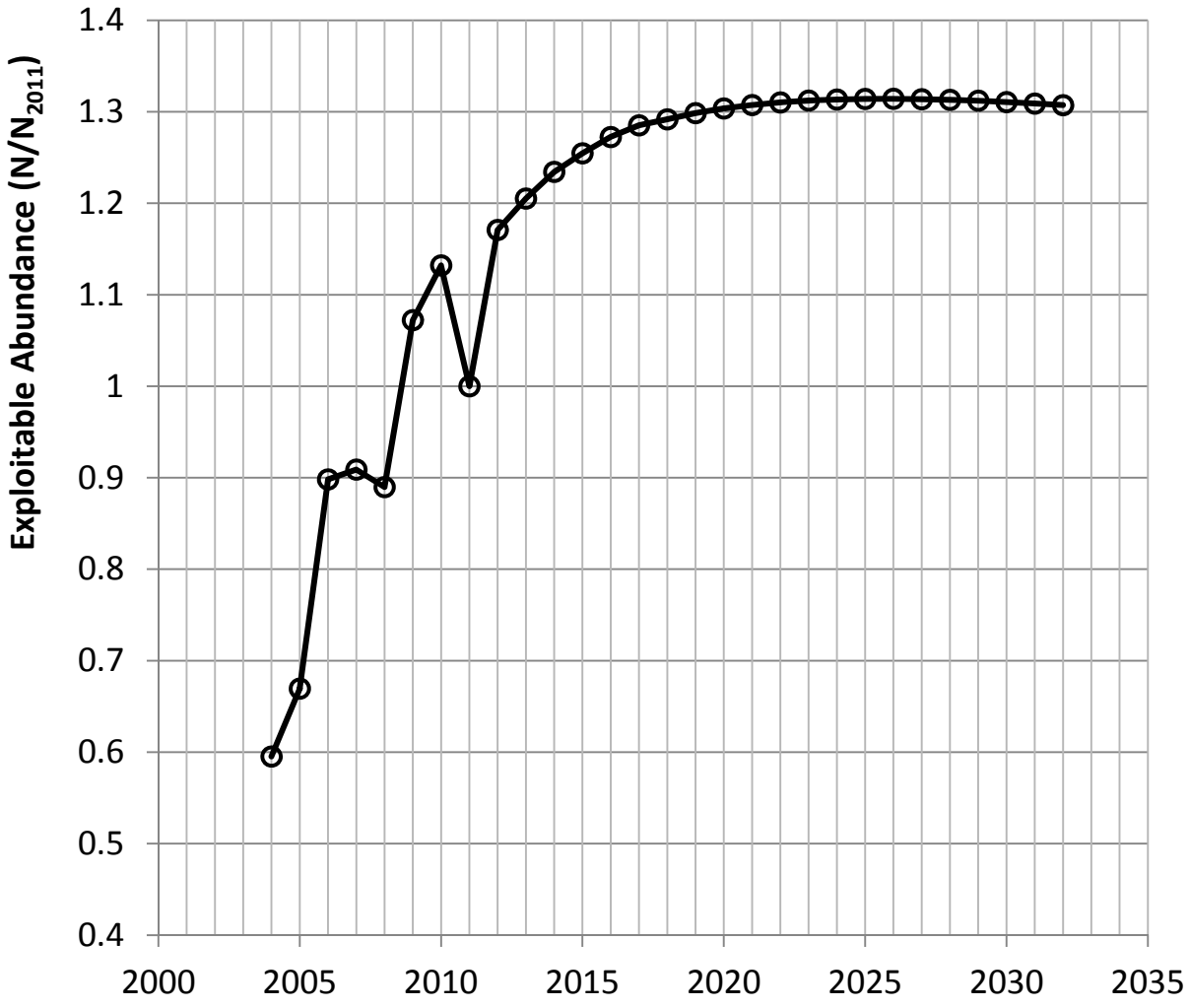

Figure 2. Projected change in abundance of recreationally exploitable Gulf red snapper relative to 2011 levels (Red Snapper SEDAR Update; B. Linton, pers. comm.).

Method 2: Effort Trends

This methodology uses trends in fishing effort, historical catch rates, and projected average weights of red snapper from the stock assessment to estimate when the quota will be reached. Data for this model were obtained from MRFSS, the TPWD creel survey, and the SEFSC Headboat survey. To calculate recreational catch in pounds per day, Equation 1 was used:

$$\frac{Catch_{lbs}^{Rec}}{day} = AvgWgt * \left(\frac{Catch_N^{For-Hire}}{trip} * \frac{Trips_N^{For-Hire}}{day} + \frac{Catch_N^{Private}}{trip} * \frac{Trips_N^{Private}}{day}\right) \quad (1)$$

where *Rec* represents both sectors combined and catch in numbers is denoted by *N*. Average weight was obtained from red snapper stock assessment projections. $Catch_N$ per trip was computed based on dividing the total number of red snapper caught by the total estimated number of angler-trips. Inputs for this parameter were computed as the average of 2009 and 2011 data: 1.23 fish/angler-trip (For-Hire) and 1.58 fish/angler-trip (Private). Trips-per-day were computed as described below.

Angler-Trips

Annual estimates of angler-trips for red snapper were computed using MRFSS, HBS, and TPWD data. An angler-trip was counted for each angler on a boat if any angler on the boat reported harvesting a red snapper. This approach is taken because if one person harvested a red snapper, theoretically, anyone on the vessel could have, because the vessel fished in waters where red snapper occur. It should be noted that this approach does not imply that all anglers caught red snapper nor caught their bag limit for red snapper, nor does the use of angler-trips in the projection imply that all anglers will catch their bag limit in subsequent years. The use of angler-trips allows for a standard scaled metric of effort across the MRFSS, HBS, and TPWD data sources.

Red snapper angler-trips were computed using MRFSS data using a modification of a catch-effort program described in Holiman (1996). The catch-effort program uses 'Type 2' (i.e., unavailable or Type B catch), 'Type 3' (i.e., available or Type A catch) and 'Type 4' (group catch) records. The program uses MRFSS effort files for expansion of intercepted catch-effort to final Gulf-wide estimates.

The SEFSC Headboat survey generates estimates of angler days, but estimates of total angler-trips are not produced. To generate estimates of angler-trips directly comparable to MRFSS, the following methods were used to produce estimates of headboat angler-trips. The SEFSC obtains office records from operators to determine the total number of angler-trips conducted by a headboat. Based on dockside interviews and sampling, the SEFSC determines if a vessel has reported or partially reported for each month. If no records are obtained from a vessel during a month, then a proxy vessel is used to estimate landings and effort. The SEFSC uses expansion factors ('K-factors') to account for trips taken with no corresponding logbook records, both for vessels with records for some of their trips during the month (e.g., A→A expansion) and for vessels with no records during the month (e.g., A→B expansion).

For the computation of catch effort for red snapper, if a vessel reported that an angler on a trip caught a red snapper, the total angler-trips for red snapper from that headboat record is equal to the total number of anglers reported on the vessel during the trip times the relevant expansion factor. If a vessel did not report during a month, but its proxy vessel had trips reporting landings of red snapper, the total angler-trips for red snapper from the non-reporting headboat is equal to the total number of anglers reported on the proxy vessel during its trips that month times the relevant A→B expansion factor.

To compute angler-trips, TPWD data were queried for the number of trips by area (i.e., state and federal waters) landing red snapper, and the number of anglers by year, area, mode, and season were summed to get observed snapper angler-trips (Dr. Mark Fisher, TPWD Science Director, pers. comm.). Next, number of anglers were summed by area to get observed angler-trips, the two data sets were match-merged, and the proportion of snapper angler-trips were calculated by dividing by total angler-trips. This proportion was then multiplied by the TPWD expanded angler-trip estimates to get snapper angler-trips.

In general, angler-trips for red snapper have increased through time, although trips have declined in 2010-2011 (Figure 3).

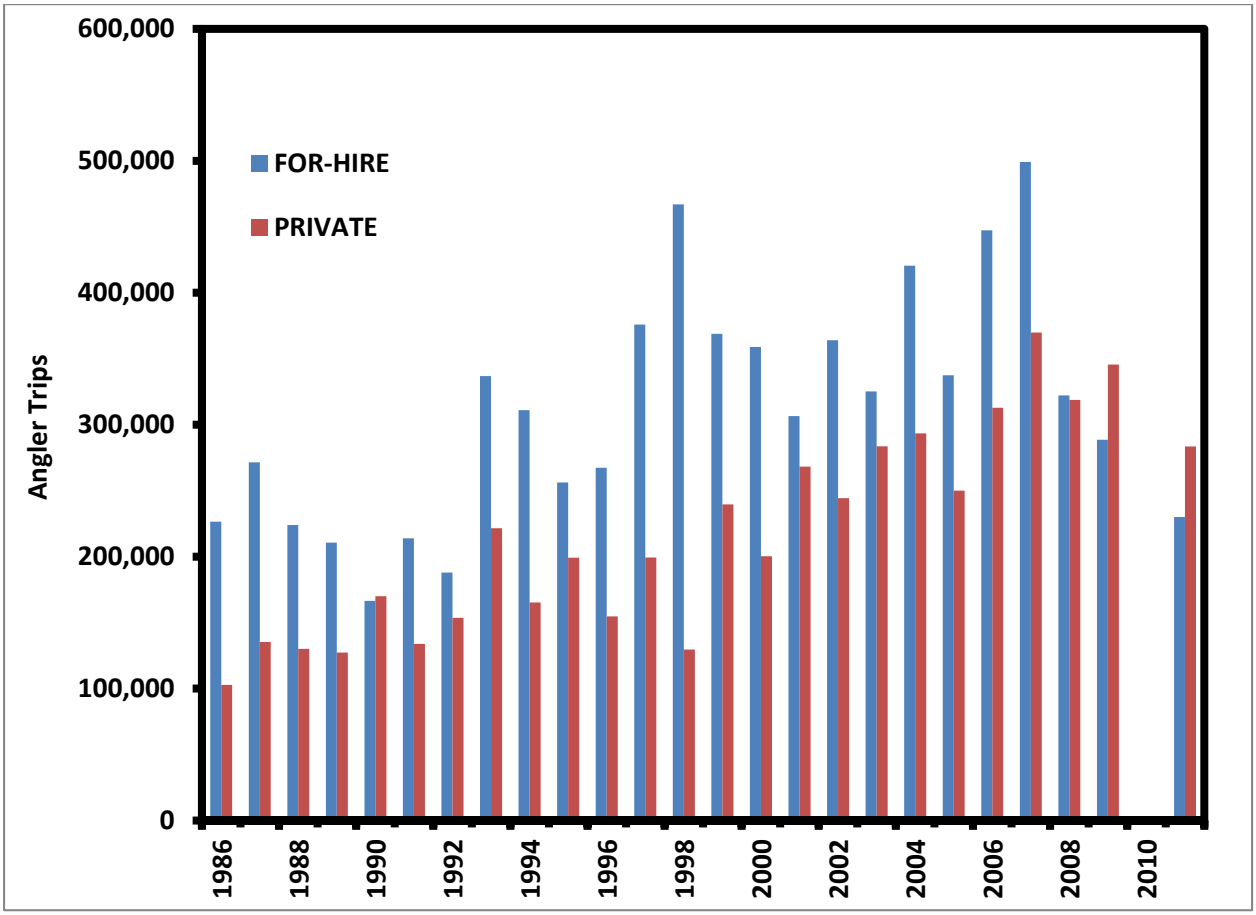

Figure 3. Angler-trips for red snapper by sector, 1986-2011. Trips during 2010 were excluded.

As fishing pressure on red snapper has intensified, management measures have become increasingly restrictive in attempts to keep the recreational sector from exceeding their quota. A primary mechanism utilized by managers has been shortening the red snapper fishing season. However, the Gulf states have not always adopted seasons compatible with the federal season. To account for this discrepancy, 'effective season length' for red snapper was computed by dividing the landings made outside the federal season by the catch rate during the federal season to determine the effective additional days of season (Table 3). These additional days were then added to the federal season to determine the effective season. Between 2009-2011, all Gulf states adopted compatible regulations with the federal season with the exception of Texas, which maintained a 365 day season.

Table 3. Effective season length (in days) for recreational red snapper, accounting for landings during time periods outside of the federal season. Note 2010 was excluded due to the oil spill.

YEAR	FEDERAL CATCH (N) PER DAY	INCOMPATIBLE LANDINGS (N)	EFFECTIVE ADDITIONAL DAYS	EFFECTIVE SEASON LENGTH
1986	3445	0	0	365
1987	2761	0	0	365
1988	3333	0	0	365
1989	2916	0	0	365
1990	1828	0	0	365
1991	2867	0	0	365
1992	4207	0	0	365
1993	5695	0	0	365
1994	4293	0	0	365
1995	3673	0	0	365
1996	3176	0	0	365
1997	4726	0	0	330
1998	4477	7501	2	274
1999	3939	48138	12	252
2000	5076	4084	1	195
2001	5434	9998	2	196
2002	7030	8486	1	195
2003	6466	5539	1	195
2004	6629	5952	1	195
2005	5190	24545	5	199
2006	6123	13448	2	196
2007	6555	66448	10	204
2008	10456	185151	18	83
2009	11761	31734	3	78
2010	-	-	-	-
2011	14434	25907	2	50

Estimates of angler-trips per day were generated by dividing the number of angler-trips by effective days open (Figure 4). As the length of the red snapper season has decreased, the number of angler trips per day has increased.

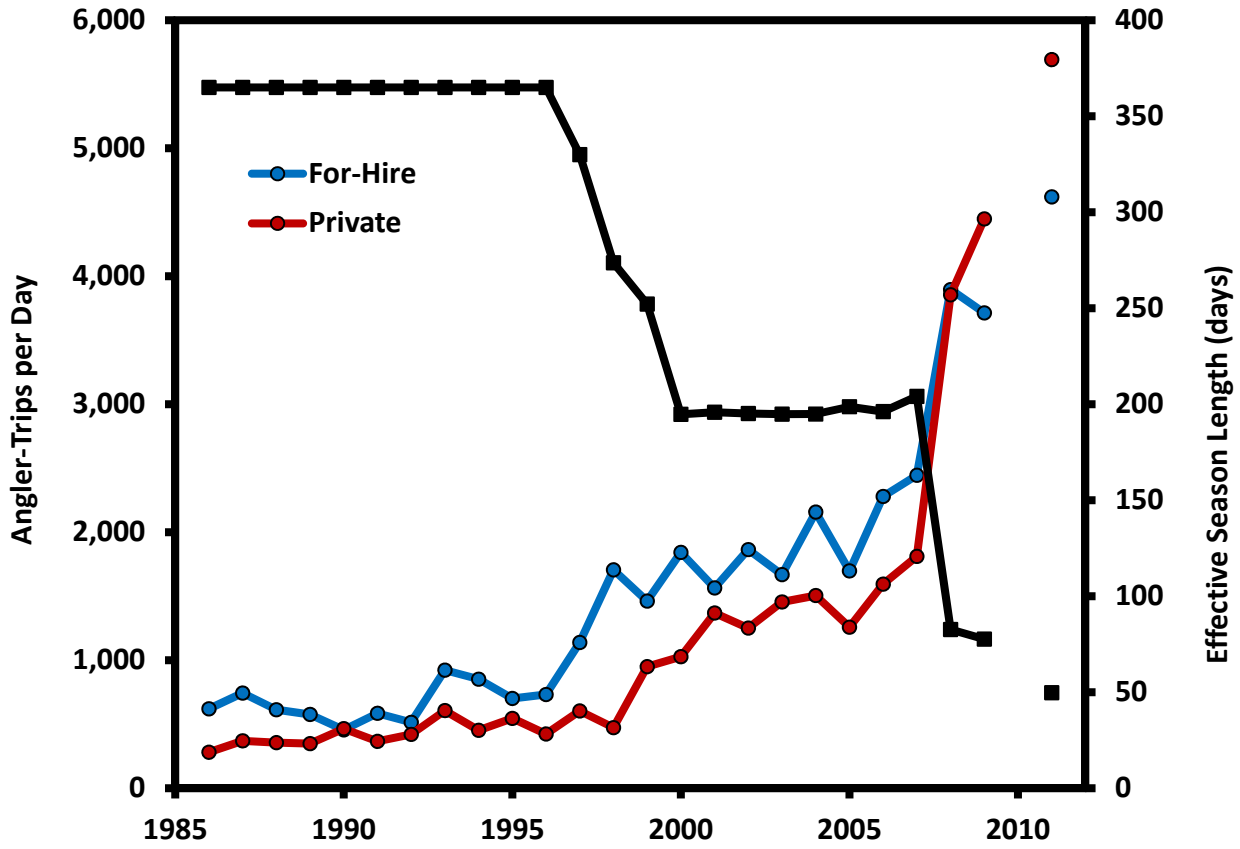

Figure 4. Red snapper angler-trips per day (red and blue lines) and effective season length (black line), 1986-2011, excluding 2010.

An important dynamic in the recreational red snapper sector that can affect season length is the ability of the recreational sectors to compensate for reductions in season length by compressing their effort into a limited season. This dynamic has been observed in other fisheries, such as the red snapper commercial fishery prior to implementation of the Individual Fishing Quota program, and is commonly referred to as 'effort compensation', 'effort stuffing', or a 'derby fishery.' The term 'effort compensation' includes the dynamics of more anglers on the water during the open season (rather than spreading their effort across the year), and the ability of individual anglers or for-hire vessels to run multiple trips in a day.

The *Curve Estimation* procedure in SPSS 17.0 (PASW Statistics Inc.) was used to fit logarithmic regressions to effective season length and angler trips per day for both the for-hire and private sectors (Figure 5). Regression fits were significant (For-Hire: $F_{1,23}$=520, p<0.001; Private: $F_{1,23}$=373, p<0.001), with log-transformed effective season lengths explaining 96% of the

variability in for-hire angler trips per day and 94% of the variability in private angler trips per day.

Predicting the ability of the fishery to compensate for a season potentially shorter than 48 days is challenging, given the lack of data beyond this point. The regression relationships in Figure 5 were used to simulate angler effort compensation under two scenarios: (1) Assuming effort compensation increases as the season gets shorter, and (2) Assuming effort compensation peaked at the highest observed annual average value (For-Hire: 4,621 angler trips per day; Private: 5,693 angler trips per day).

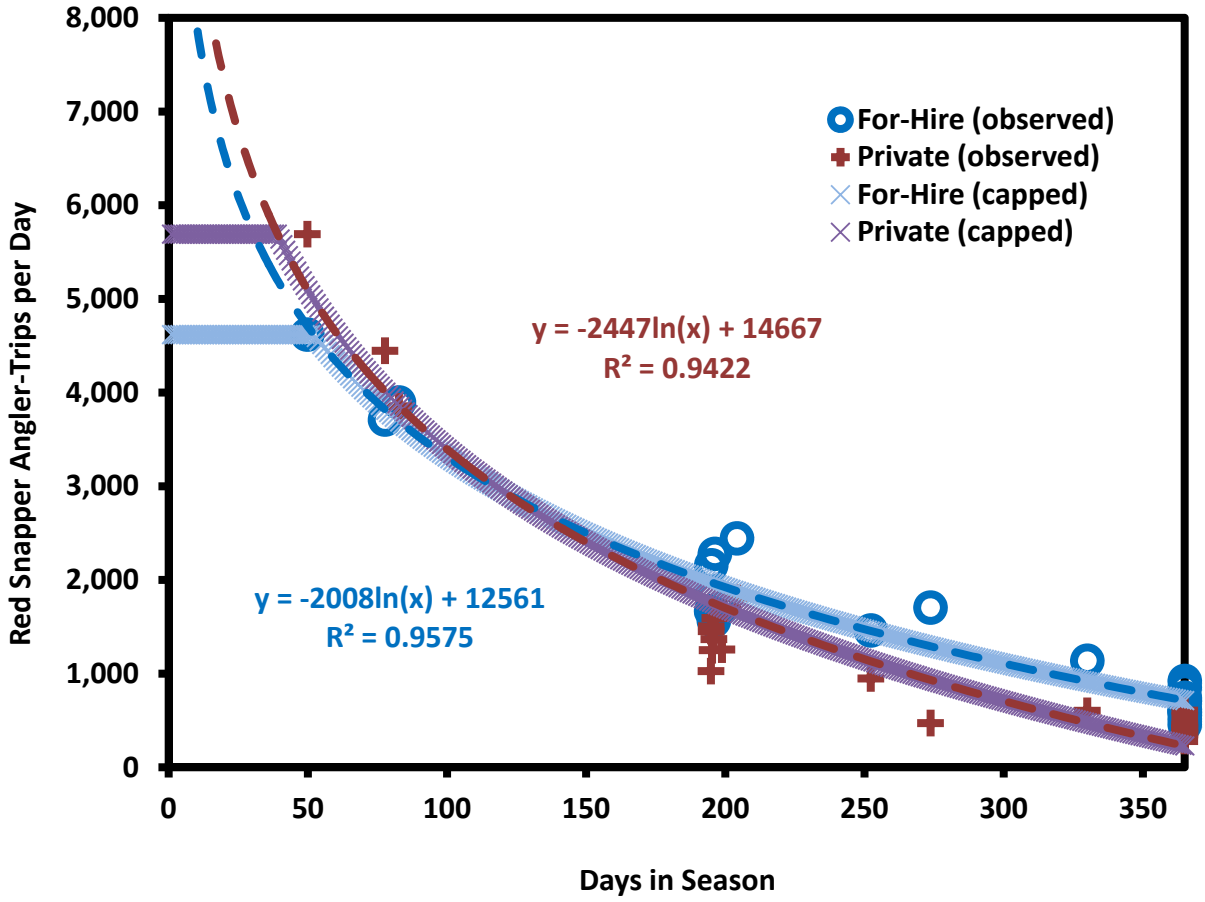

Figure 5. Logarithmic relationship between red snapper angler-trips per day relative to effective season length used to predict effort compensation dynamic. Dotted lines represent simulated effort compensation with saturation at highest observed point.

The maximum allowable season is estimated utilizing *Solver* to calculate the effective season length that would minimize the difference between the projected catch and the allocated catch. As Texas is not expected to adopt compliant regulations, the projected 2012 season under Method 2 was reduced by 2 days, consistent with the adjustment in 2011 (Table 1).

Method 3: Regression

The third method regressed landings per federal season day versus year. A linear regression (± 80% confidence limits) was fit to catch rate data by year for 2007-2011, excluding 2010 (Figure 6). The regression was then used to predict the landings per federal season day for the 2012 fishing year. Catch data for 2010 were excluded from the regression because fishery closures resulting from the Deepwater Horizon oil spill reduced harvest rates during the core summer fishing season. Landings used in the regression were obtained from the SEFSC's ACL database. Landings were removed from catch per day computations if they did not occur when the federal season was open. MRFSS and TPWD, landings were removed if they occurred in waves when the red snapper federal season was not open. For headboat, landings were excluded if they were reported in months when the federal season was not open. Landings not occurring during the federal season were then summed and the following equation was used to predict the federal season length.

$$\boldsymbol{Quota_{2012} = 17,132 * Days_{federal} - 34,358,258 + \sum Landings_{non-federal}}$$

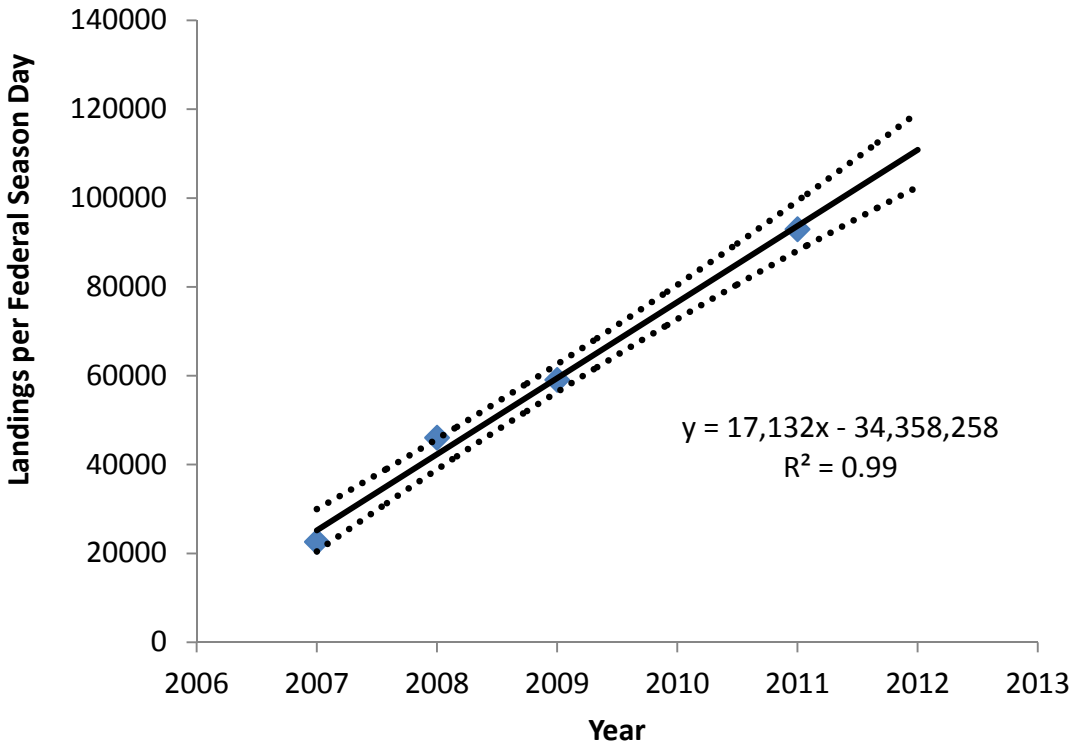

Figure 6. Linear regression (± 80% confidence limits) of landings per federal season day versus year, 2007-2011 (excluding 2010).

Results and Discussion

The recreational Gulf of Mexico red snapper quota is projected to be met in early to mid-July, if all Gulf States except Texas adopt fishing seasons consistent with the federal fishing season (Tables 4-6). If Gulf States do not adopt consistent fishing seasons, then the federal fishing season is expected to be substantially shorter than predicted herein. Season length projections summarized in Methods 1 and 2 are sensitive to the predicted average weight of a landed red snapper. Reported average weights of red snapper during 2009 and 2010 were 4% and 5% less than projected by the Red Snapper SEDAR Update (B. Linton, SEFSC, pers. comm.), respectively. Reported average weight in 2011 was 4% higher than projected. Model runs explored season lengths using average weights as projected (6.34 lbs/fish), as projected plus 5% (6.65 lbs/fish), and as projected plus 10% (6.97 lbs/fish).

Method 1: SARIMA Model

Diagnostic plots suggested a (0,0,1)(1,1,0) SARIMA model for monthly recreational red snapper catch per day was an appropriate model structure (see Appendix). The model indicates a strong seasonal trend, with the highest landings during the federal open season (Figure 7). Converting projected catch-in-numbers to catch-in-pounds using a projected average weight of 6.39 pounds whole weight, the 2012 ACL of 75% of OFL = 3.959 mp ww is projected to be met on July 9, 2012 (Table 4). A federal season of 38 days is anticipated to prevent the ACL from being exceeded. If average weights are 5% higher than projected, the ACL would be met by July 7, 2012 (Table 4). A federal season of 36 days would be needed to reduce the risk of an overage. If average weights are 10% higher than projected, the ACL would be met by July 5, 2012. A federal season of 34 days would be needed to reduce the risk of an overage (Table 4). The run of the SARIMA model with 2011 data dropped fit the actual 2011 data with a mean prediction percent error within the federal season of 7% (underestimated 5% in June and 9% in July).

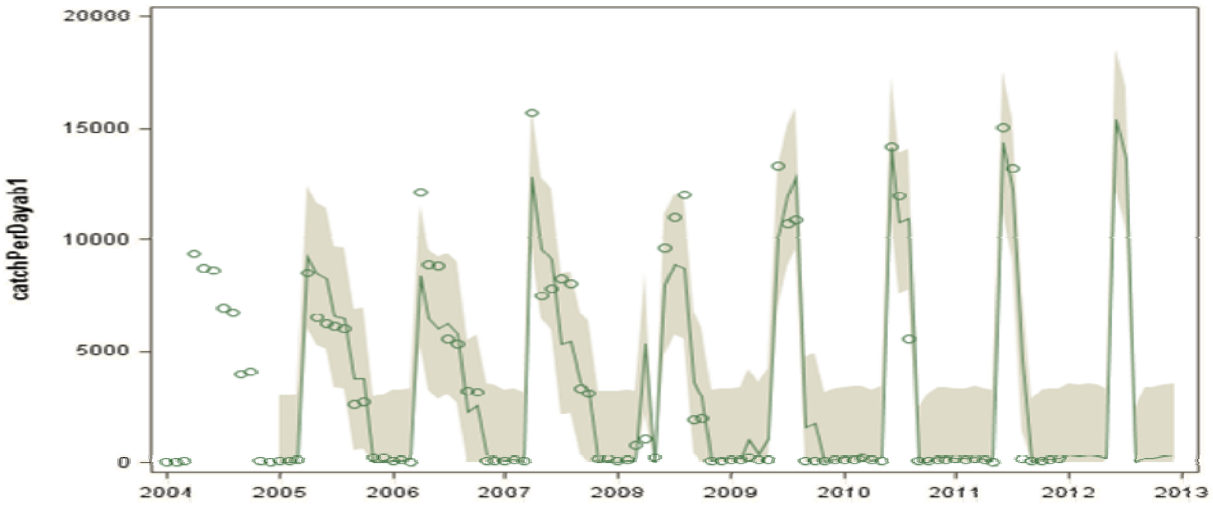

Figure 7. SARIMA model fit to recreational catch-per-day (in numbers). Bands indicate 95% confidence limits.

Method 2: Effort Trends Model

Method 2 (Effort Trends Model) predicted season lengths of 39, 36, and 33 days for average weights at projected, projected plus 5%, and projected plus 10%, respectively, and assuming effort compensation continues to increase beyond the highest observed values (Table 5). If effort compensation is capped at the highest observed values, Method 2 (Effort Trends Model) predicts season lengths of 41, 39, and 36 days for average weights at projected, projected plus 5%, and projected plus 10%, respectively (Table 5).

Method 3: Regression Model

The linear regression fit extremely well ($F_{1,2}$=241, p<0.01) with 99 percent of the variance in landings per day explained by year (Figure 6). Method 3 predicted a season length of 34 days based on mean projected landings per federal season day, with an 80% confidence limit range of 32-37 days (Table 6).

Table 4. Projected 2012 recreational red snapper federal season lengths using Method 1.

Scenario	Avg Weight	Federal Season	Days Open
1	6.34	Jun 1-Jul 8	38
2	6.65	Jun 1-Jul 6	36
3	6.97	Jun 1-Jul 4	34

Table 5. Projected 2012 recreational red snapper federal season lengths using Method 2.

		Days Open If:	
Scenario	Avg Weight	Effort Comp Saturates	Effort Comp Continues
1	6.34	41	39
2	6.65	39	36
3	6.97	36	33

Table 6. Projected 2012 recreational red snapper federal season lengths using Method 3.

Scenario	Federal Season	Days
Mean	Jun 1-Jul 4	34
80% UCL	Jun 1- Jul 2	32
80% LCL	Jun 1- Jul 7	37

Discussion

Method 1 (SARIMA Model) estimates the season length to be between 34 and 38 days depending on the average weight of red snapper harvested. Method 2 estimates the season length to be between 36 and 41 days if effort saturates at the highest observed levels, and between 33 and 39 days if effort compensation continues to increase as the season is shortened (see Figure 5). Similar to Method 1, the length of the season estimated by Method 2 is contingent on the average weight of red snapper harvested. Method 3 does not explicitly account for changes in average weights of red snapper, although they are implicitly incorporated in the regression of pounds/day vs. time. Method 3 predicts the season length to be between 32 and 37 days. The predicted season length ranges from 32 to 41 days across all model runs evaluated, with mean and median season length for all projections equal to 36 days.

Method 1 uses historical trends in the fishery over the long-term and the immediate past to influence model dynamics, while also accounting for changes in average weight and perturbations resulting from major management changes. Method 2 allows effort to either saturate at peak historic levels or continue to increase as the season length is reduced beyond the shortest observed. Model 3 relies on short term trends in daily catch rates to predict future catch. If 2012 effort is lower than projected, owing to high fuel prices, after-effects of the BP/DeepWater Horizon oil spill, and economic factors, then a longer season than those presented in this report might be required to catch the entire recreational quota.

Setting the season length based on shorter season estimates will reduce the risk of a quota overage, but increases the likelihood that the quota may not be harvested. Increases in the recreational quota are contingent on the annual catch limit not being exceeded in the prior fishing year. If the annual catch limit is exceeded, then the quota would not be increased. Additionally, if the fixed summer season results in an underage in quota harvested, the NOAA Fisheries Service Assistant Administrator has authority to reopen the recreational red snapper season to harvest any remaining quota (50 CFR 622.42).

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Appendix

Table A1. Input data for catch-per-day SARIMA model.

Date	Days	Fed Season	HBS ab1	MRFSS ab1	TPWD ab1	TOTAL ab1	Catch Per Day
1-Jan-04	31	0	910	56	64	1030	33.222208
1-Feb-04	29	0	144	52	60	256	8.832886732
1-Mar-04	31	0	1357	0	0	1,357	43.77419355
1-Apr-04	30	10	15113	75,250	3,319	93,682	9368.177833
1-May-04	31	31	31875	232,112	5,605	269,592	8696.508805
1-Jun-04	30	30	28078	224,624	5,424	258,126	8604.216331
1-Jul-04	31	31	34498	171,472	7,984	213,954	6901.743463
1-Aug-04	31	31	27920	171,472	7,984	207,376	6689.549914
1-Sep-04	30	30	15289	98,847	4,690	118,827	3960.890807
1-Oct-04	31	31	18481	102,142	4,847	125,470	4047.418764
1-Nov-04	30	0	144	695	390	1,229	40.97213012
1-Dec-04	31	0	2	718	403	1,123	36.23664625
1-Jan-05	31	0	360	21	893	1,274	41.08701637
1-Feb-05	28	0	904	19	806	1,729	61.75982743
1-Mar-05	31	0	3254	0	0	3,254	104.9677419
1-Apr-05	30	10	14747	65,521	4,762	85,030	8503.032952
1-May-05	31	31	33291	164,429	4,053	201,773	6508.810847
1-Jun-05	30	30	23986	159,125	3,922	187,033	6234.440955
1-Jul-05	31	31	22079	153,732	13,050	188,861	6092.303464
1-Aug-05	31	31	19038	153,732	13,050	185,820	5994.20669
1-Sep-05	30	30	12241	61,685	3,794	77,720	2590.672876
1-Oct-05	31	31	15931	63,742	3,920	83,593	2696.542768
1-Nov-05	30	0	443	3,383	3,656	7,482	249.4092404
1-Dec-05	31	0	505	3,496	3,778	7,779	250.9328963
1-Jan-06	31	0	1793	0	880	2,673	86.22854019
1-Feb-06	28	0	2609	0	795	3,404	121.5684019
1-Mar-06	31	0	1031	0	0	1,031	33.25806452
1-Apr-06	30	10	16528	94,999	9,358	120,885	12088.4681
1-May-06	31	31	27693	238,090	9,372	275,155	8875.954701
1-Jun-06	30	30	24826	230,410	9,069	264,305	8810.165454
1-Jul-06	31	31	30715	130,785	10,376	171,876	5544.381916
1-Aug-06	31	31	22948	130,785	10,376	164,109	5293.833529
1-Sep-06	30	30	20819	70,324	5,451	96,594	3219.814873
1-Oct-06	31	31	18685	72,668	5,633	96,986	3128.590142
1-Nov-06	30	0	538	464	971	1,973	65.77028139
1-Dec-06	31	0	874	479	1,004	2,357	76.03049644
1-Jan-07	31	0	1050	26	602	1,678	54.14504153
1-Feb-07	28	0	2392	24	544	2,960	105.7026452
1-Mar-07	31	0	1955	0	0	1,955	63.06451613
1-Apr-07	30	10	20564	133,176	2,881	156,621	15662.06717
1-May-07	31	31	25125	201,644	5,351	232,120	7487.729844
1-Jun-07	30	30	33382	195,139	5,178	233,699	7789.979306
1-Jul-07	31	31	32422	211,628	10,637	254,687	8215.702653
1-Aug-07	31	31	26271	211,628	10,637	248,536	8017.283298
1-Sep-07	30	30	17129	78,539	3,582	99,250	3308.330249
1-Oct-07	31	31	10987	81,157	3,701	95,845	3091.782937
1-Nov-07	30	0	1458	2,167	1,812	5,437	181.2423068
1-Dec-07	31	0	1182	2,240	1,872	5,294	170.7713391

1-Jan-08	31	0	575	45	1,014	1,634	52.72102477
1-Feb-08	29	0	1761	42	949	2,752	94.8967756
1-Mar-08	31	0	4516	15,981	2,805	23,302	751.6707722
1-Apr-08	30	0	13383	15,465	2,715	31,563	1052.093353
1-May-08	31	0	6472	0	0	6,472	208.7741935
1-Jun-08	30	30	35053	250,220	4,288	289,561	9652.037494
1-Jul-08	31	31	39496	283,746	17,732	340,974	10999.14674
1-Aug-08	31	4	9021	36,612	2,288	47,921	11980.33223
1-Sep-08	30	0	2902	52,479	1,466	56,846	1894.882543
1-Oct-08	31	0	5155	54,228	1,514	60,898	1964.439532
1-Nov-08	30	0	491	0	822	1,313	43.76010929
1-Dec-08	31	0	730	0	849	1,579	50.94182972
1-Jan-09	31	0	2511	0	324	2,835	91.45762712
1-Feb-09	28	0	3522	0	293	3,815	136.2433414
1-Mar-09	31	0	6738	0	703	7,441	240.0433633
1-Apr-09	30	0	3525	0	681	4,206	140.1885246
1-May-09	31	0	3536	0	0	3,536	114.0645161
1-Jun-09	30	30	53872	336,313	8,422	398,607	13286.90738
1-Jul-09	31	31	53953	264,543	12,586	331,082	10680.07053
1-Aug-09	31	14	27221	119,471	5,684	152,376	10884.00832
1-Sep-09	30	0	291	725	1,100	2,116	70.5444557
1-Oct-09	31	0	690	749	1,137	2,576	83.10252022
1-Nov-09	30	0	481	0	1,700	2,181	72.70546448
1-Dec-09	31	0	1248	0	1,757	3,005	96.93019566
1-Jan-10	31		2906	0	1,073	3,979	128.3605796
1-Feb-10	28		2900	0	969	3,869	138.1900726
1-Mar-10	31		5096	146	1,455	6,697	216.0238349
1-Apr-10	30		2204	141	1,408	3,753	125.0867381
1-May-10	31		1768	0	0	1,768	57.03225806
1-Jun-10	30		58354	357,721	8,422	424,497	14149.8853
1-Jul-10	31		49831	221,988	12,586	284,405	11943.60959
1-Aug-10	31		13611	59,736	5,684	79,030	5533.681579
1-Sep-10	30		146	376	1,100	1,622	54.07070115
1-Oct-10	31		345	389	1,137	1,871	60.34973341
1-Nov-10	30		373	873	1,700	2,946	98.18699621
1-Dec-10	31		1184	902	1,757	3,843	123.9638779
1-Jan-11	31	0	3301	0	1,822	5,123	165.263532
1-Feb-11	28	0	2278	0	1,646	3,924	140.1368039
1-Mar-11	31	0	3454	292	2,207	5,952	192.0043065
1-Apr-11	30	0	882	282	2,135	3,300	109.9849517
1-May-11	31	0	0	0	0	0	0
1-Jun-11	30	30	62835	379,129	8,422	450,386	15012.86322
1-Jul-11	31	18	45709	179,434	12,586	237,729	13207.14866
1-Aug-11	31	0	0	0	5,684	5,684	183.3548387
1-Sep-11	30	0	0	28	1,100	1,128	37.5969466
1-Oct-11	31	0	0	29	1,137	1,166	37.5969466
1-Nov-11	30	0	264	1,746	1,700	3,710	123.6685279
1-Dec-11	31	0	1120	1,804	1,757	4,681	150.9975602

Sources: SEFSC ACL Recreational Dataset (Apr 2012), Red Snapper SEDAR Update (2011).

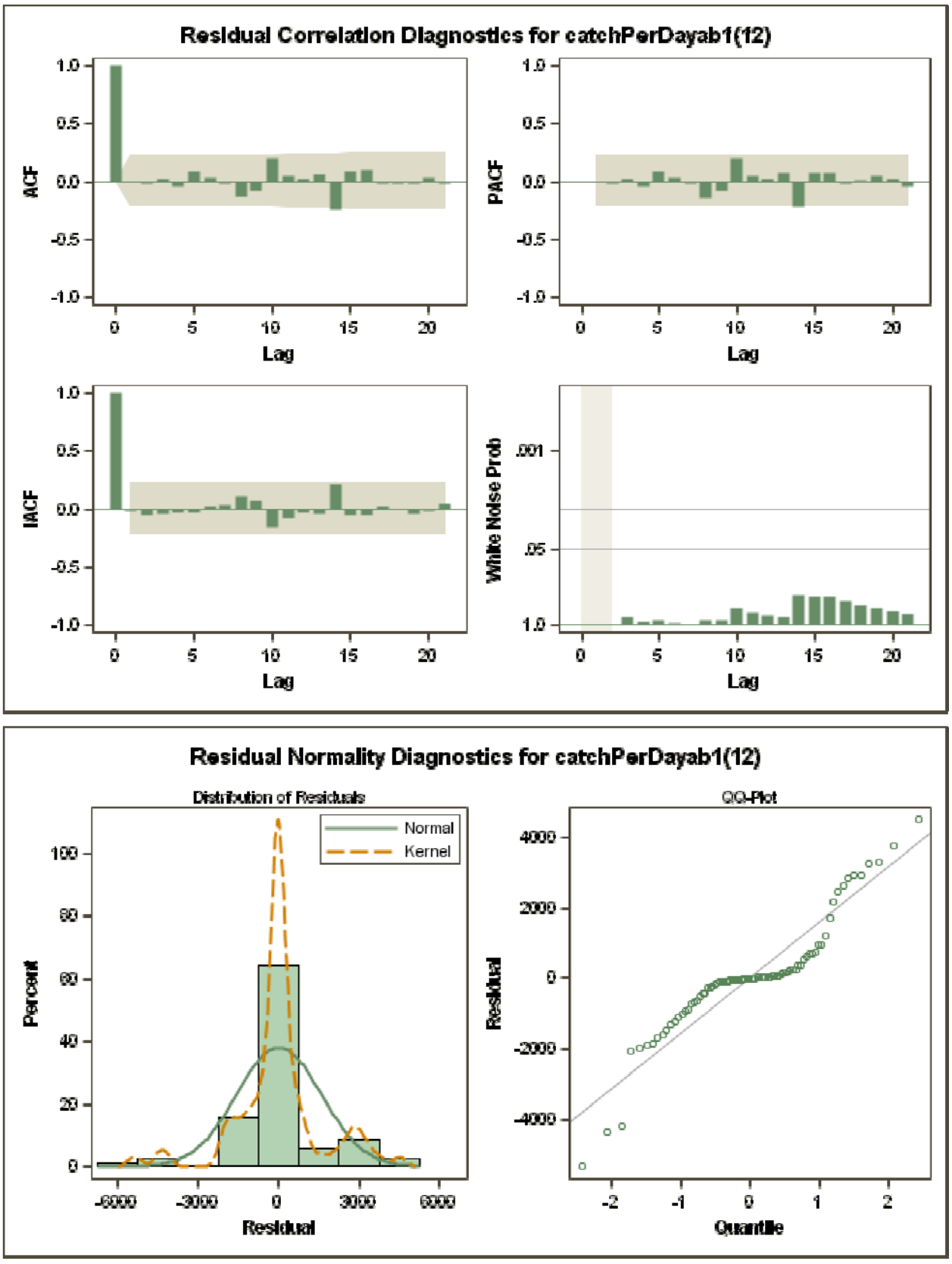

Figure A1. Model diagnostics for Gulf red snapper recreational catch-per-day in numbers fit to a SARIMA(1,0,0)(0,1,1) model.